Vibration reduction methods and techniques for rotorcraft utilizing on-blade active control, Phase I

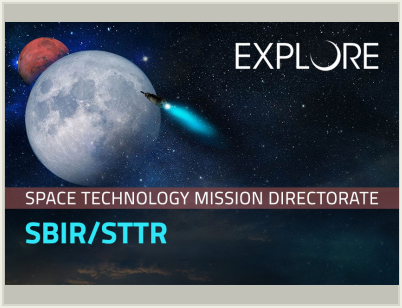
Completed Technology Project (2007 - 2007)

Project Introduction

Rotor blades adapted for vibration control have the added benefit of extended blade and rotor life, as well as improved passenger comfort. Approaches that have been explored for on-blade active control or individual blade control include control surface actuation, such as trailing edge flaps, and integrated blade manipulation, such as controllable twist. For retro-fit and upgrade purposes, the advanced rotor system needs an actuation scheme with appropriate force, deflection, and bandwidth, without detrimentally increasing on-blade mass. Research in this area has been conducted with potential solutions employing various conventional active material actuator configurations, but these systems have typically suffered from inherent disadvantages. Due to these limitations, Techno-Sciences, Inc. proposes the use of pneumatic artificial muscles to actuate a trailing edge flap device for management of rotorcraft vibration. The proposed actuators are constructed of passive materials that are very mass efficient and low cost, while maintaining adequate force, stroke, and bandwidth. Oriented along the blade span and located within the airfoil contour near the blade root, the antagonistic configuration of actuators offers bi-directional flap deflection and operation under a low centrifugal field. A lightweight mechanism accompanies the actuators, running along the span, to transfer and tailor the mechanical work from the actuators to the span station of the flap. The proposed research plan will work to properly size and scale the actuators and mechanism for the desired response, and construct a prototype device that demonstrates the feasibility of the concept on the bench-top and in a rotating environment at full-scale loading.

Anticipated Benefits

Potential NASA Commercial Applications: The pneumatically actuated, trailing edge flap device for rotorcraft vibration control will be applicable to a wide range of end-users in the defense, commercial, and industry sectors. Its broad applicability is enabled by the scalability of the pneumatic artificial muscles for the entire range of small unmanned vehicles to larger transport vehicles. In addition to the noted NASA applications, vibration control in vertical take-off and landing systems is attractive to the military for tasks such as mine detection, troop insertion and extraction, and biochemical weapons cleanup; and commercial and industry tasks such as construction in hazardous terrain, maintenance of bridges and buildings, and storm tracking. The proposed flap technology will be an integrated hardware/software product that can be licensed for manufacture. Techno-Sciences, Inc. already enjoys market share of related technologies through our existing customers, and we plan to leverage these marketing outlets and offer pneumatic artificial muscle flap systems for advanced rotor upgrade packages. Potential Non-NASA Commercial Applications: Throughout the Phase I effort, Techno-Sciences, Inc. will work in concert with NASA sponsors to ensure that the proposed trailing edge flap device operated with pneumatic artificial muscles can be seamlessly



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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

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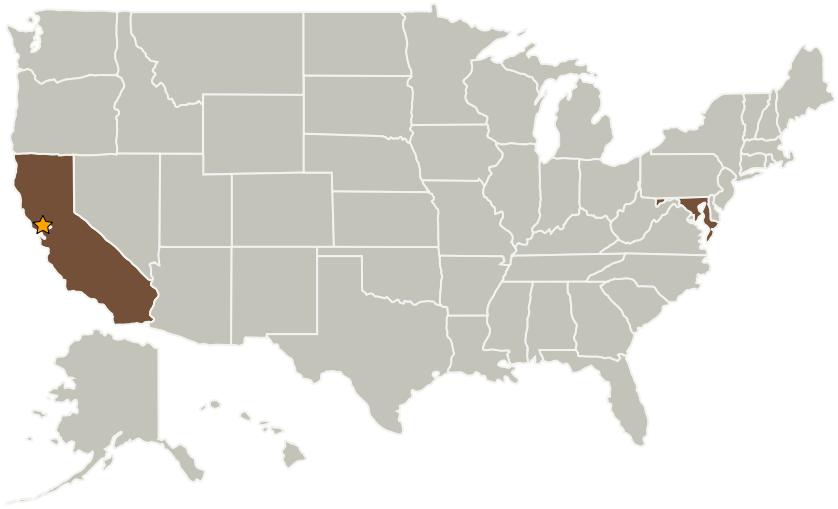
integrated with existing rotor blade systems and future vertical flight technologies currently in development. These include single or multiple passenger vehicles for transportation, search and rescue operations, and package delivery, in addition to unmanned vehicles for meteorological and atmospheric measurements, operations in hazardous environments, and traffic control. To facilitate technology transfer, we will work in Phase I to address top-level hardware and software integration issues from a systems engineering perspective. Issues such as control electronics, software architectures, hardware interfaces, manufacturability, ruggedness, and reliability will be considered in Phase I and implemented in Phase II of the program.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
Techno-Sciences, Inc.	Supporting Organization	Industry	Beltsville, Maryland

Primary U.S. Work Locations	
California	Maryland

Project Management

Program Director:
Jason L Kessler

Program Manager:
Carlos Torrez

Project Manager:
William G Warmbrodt

Principal Investigator:
Curt Kothera

Technology Areas

Primary:

- TX15 Flight Vehicle Systems
  - TX15.1 Aerosciences
    - TX15.1.5 Propulsion Flowpath and Interactions

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Project Transitions

January 2007: Project Start

July 2007: Closed out

Closeout Summary: Vibration reduction methods and techniques for rotorcraft utilizing on-blade active control, Phase I Project Image